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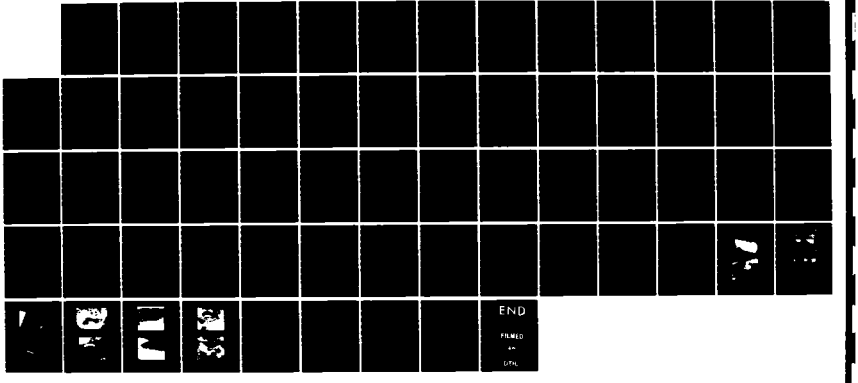

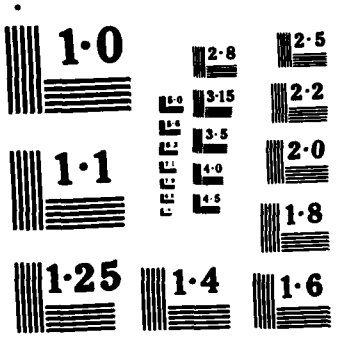

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TNT EQUIVALENCY OF M31A1E1 SLOTTED STICK PROPELLANT

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18. SUPPLEMENTARY NOTES

This project was accomplished as part of the U.S. Army's Manufacturing Methods and Technology program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in production of Army materiel. (cont)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Peak side-on blast overpressure and scaled positive impulse have been measured for M31A1E1 slotted stick propellant. The equivalency testing addressed the shipping container. High explosive equivalency values for each test series were obtained as a function of scaled distance by comparison to known pressure and impulse characteristics for TNT hemispherical surface bursts.

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18. SUPPLEMENTARY NOTES (cont)

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SUMMARY

M31A1E1 slotted stick propellant was detonated in its proposed final pack-out configurations. The proposed final pack-out configurations are two 27.22-kg (60-lb) fiberboard cartons in a 54.43-kg (120-lb) wooden box. A single fiberboard carton with 27.22-kg (60-lb) charge weight and a wooden box with a 54.43-kg (120-lb) charge weight (two fiberboard cartons) were tested. Blast output parameters were measured and the TNT equivalency values were computed based on the comparison with TNT hemispherical surface bursts.

Test results indicate that pressure and impulse values were dependent upon the physical characteristics of the propellant and the geometric configuration in which the propellant was detonated. For M31A1E1 slotted stick propellant in a 27.22-kg (60-lb) fiberboard carton, the geometric configuration produced an effect that was significantly different on each gage line. Blast output for the gage line facing the short side of the fiberboard carton was much lower than the blast output along the gage line facing the long side of the fiberboard carton. The effects were more pronounced for the close-in measurements. For the M31A1E1 slotted stick propellant in a wooden box containing two 27.22-kg (60-lb) cartons, the difference in blast output along each gage line was not as significant. An average value for the TNT equivalency values for the two configurations showed the equivalency values to be greater than 100 percent at the near field scaled distances $\leq$ 2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$) and less than 100 percent at the far field scaled distances $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$).

Configuration	TNT Equivalency (%) at Scaled Distance											
	1.19 m/kg$^{1/3}$ (3.0 ft/lb$^{1/3}$)		1.59 m/kg$^{1/3}$ (4.0 ft/lb$^{1/3}$)		2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$)		3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$)		7.14 m/kg$^{1/3}$ (18.0 ft/lb$^{1/3}$)		15.87 m/kg$^{1/3}$ (40.0 ft/lb$^{1/3}$)	
	P	I	P	I	P	I	P	I	P	I	P	I
Simulated fiberboard carton (average values) 27.22 kg (60 lb)	214	126	159	94	164	122	87	72	69	44	38	41
Short side (odd) gage line simulated fiberboard carton 22.68 kg (60 lb)	61	47	45	26	37	38	86	54	86	43	46	37
Long side (even) gage line simulated fiberboard carton 27.22 kg (60 lb)	368	206	272	161	291	206	87	90	53	45	30	45
Simulated wooden box (average values) 54.43 kg (120 lb)	157	159	138	65	125	60	54	64	62	52	64	66
Short side (odd) gage line simulated wooden box 54.43 kg (120 lb)	139	141	97	48	76	37	50	53	65	42	86	81
Long side (even) gage line simulated wooden box (54.43 kg (120 lb)	175	179	179	88	174	83	59	74	59	58	43	52

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ILLUSTRATIONS

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INTRODUCTION

Background

The M31A1E1 slotted stick propellant is a solvent, triple-base propellant which will be utilized in the M203E2 Propelling Charge (155mm cannon). The raw materials are blended and mixed, blocked, pressed and cut to size. During these operations the propellant is in a wet condition and relatively insensitive. The sticks are placed in trays and open racks for air drying, then sorted and inspected, placed into pack-out cartons and loaded into storage magazines for shipment.

The chemical constituents of M31A1E1 slotted stick propellant by percent weight are:

Constituent	Weight %
Nitrocellulose	21.50
Nitroglycerin	18.00
Nitroguanidine	54.70
Dibutylphthlate	3.00
Ethyl centralite	1.50
Potassium sulfate	1.25
Carbon black	0.25
Total	100.00

Propellant Dimensions mm (inches):

Length	736.6 (29)
Diameter	6.35 (0.250)
Perforation Diameter	2.18 (0.086)
WEB	2.08 (0.082)

The test results reported were conducted in accordance with Facility Projects 5840084 and 5872307 as an engineering effort to provide TNT equivalency data for the proposed final pack-out configurations for M31A1E1 slotted stick propellant.

Objective

The objective of this test program was to determine the maximum blast output from the detonation of M31A1E1 slotted stick propellant in its shipping/storage container. The measured pressure and impulse data were compared with that produced by a hemispherical surface burst of TNT and the TNT equivalency of M31A1E1 slotted stick propellant determined.

EXPERIMENTAL METHODS

Materials

Test material was M31A1E1 slotted stick propellant. The M31A1E1 slotted stick propellant was received from Radford Army Ammunition Plant, Radford, Virginia 24141.

Test Plan

Blast parameters of pressure and impulse were evaluated for weights and configurations of M31A1E1 slotted stick propellant in its proposed shipping/storage container. It is proposed that the final pack-out configuration will be two 27.22-kg (60-lb) net weight fiberboard cartons in a 54.43-kg (120-lb) net weight wooden box. Both of above configurations are full-scale simulations. No attempt was made to determine the effects of scaling. Physical characteristics of the proposed shipping/storage container for the test program are as follows:

1. An orthorhombic container (figure 1a) with a charge weight of 27.22 kg (60 lb) of M31A1E1 slotted stick propellant was used to simulate the fiberboard carton. The carton was constructed from fiberboard with the following inside dimensions: 74.93 cm (29.5 inches) long, 19.685 cm (7.75 inches) wide and 19.05 cm (7.5 inches) high.

2. An orthorhombic container (figure 1b) with a charge weight of 54.43 kg (120 lb) of M31A1E1 slotted stick propellant was used to simulate the proposed final pack-out configuration of two 27.22 kg (60 lb) fiberboard cartons in a wooden box. The wooden box was constructed from plywood with the following inside dimensions 77.47 cm (30.5 inches) long, 41.91 cm (16.5 inches) wide and 20.32 cm (8.0 inches) high.

Each test charge was initiated with a J2 blasting cap and a conically shaped booster of Composition C4 high explosive. Due to the physical characteristics of the propellant and the orientation of the propellant in its container, a 5 percent booster seemed to be marginal in achieving a high order detonation. Consequently a 10 percent booster was used to achieve a high order detonation. For the 54.43-kg (120-lb) charge weight it was necessary to place a booster and J2 blasting cap on each 27.22-kg (60-lb) fiberboard carton in the wood box for a total booster weight of 5.44 kg (12-lb). Results were consistent and there was no evidence of any unreacted propellant; thus, because of the physical characteristic of the propellant and the physical form of the containers, the propellant seems to be less sensitive to shock initiation by an explosive.

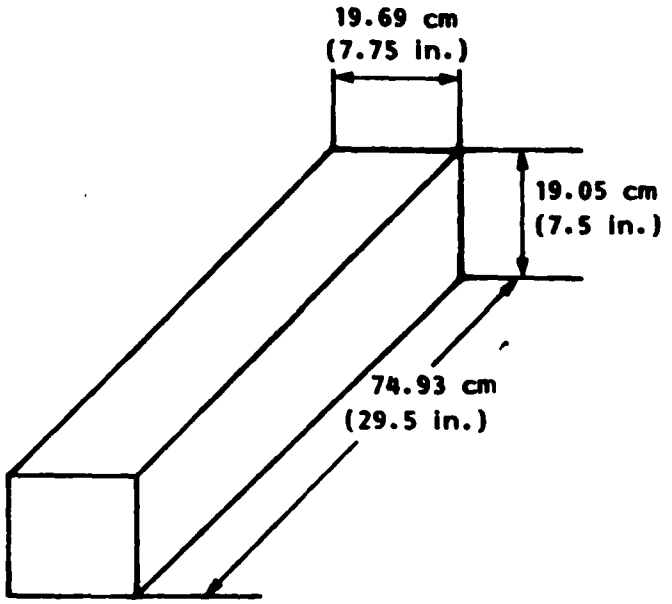


Figure 1a. Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight

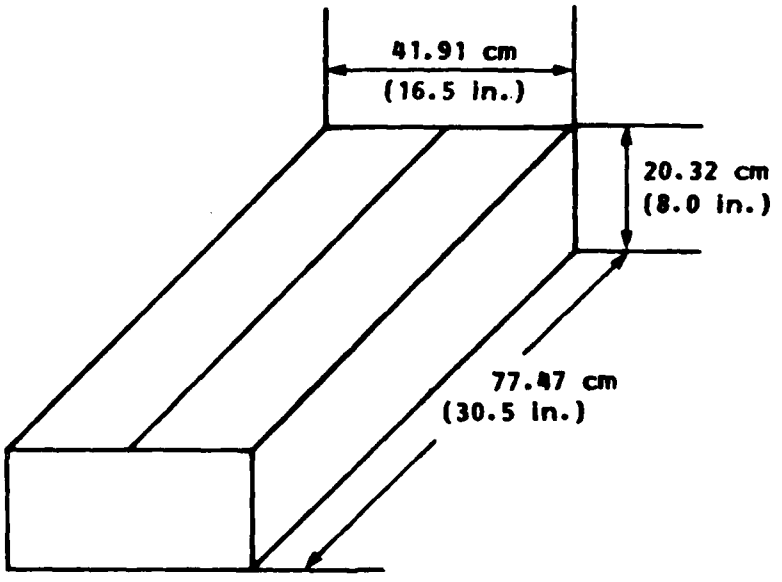


Figure 1b. Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight

The test charge for each configuration was placed on a 1010 carbon-steel witness plate, 1.27 cm (0.5 inches) thick with the outside dimensions 15.2 cm (6 inches) larger than the base of the test configuration dimensions. Figure 2 shows the test area. The area was refurbished after each test subsequent to measurement ot crater diameter and depth.

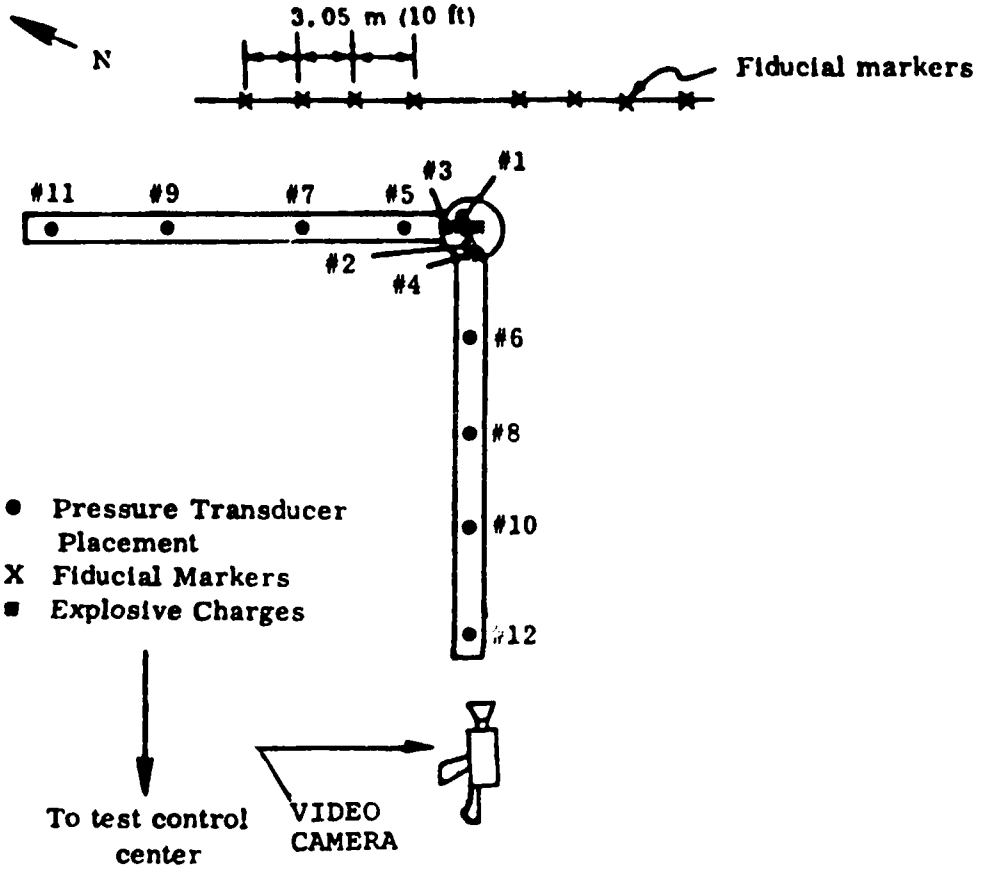


Figure 2. Test Area Showing Charge Placement, Transducer Placement, and Camera Placement

Instrumentation

Twelve side-on pressure transducers were mounted and placed at ground level in two 90-degree arrays within the test area shown in figure 2. Distances between the transducers and charge were calculated to correspond to scaled distances of 1.19, 1.59, 2.14, 3.57, 7.14 and 15.87 $m/kg^{1/3}$ (3.0, 4.0, 5.4, 9.0, 18.0 and 40.0 $ft/lb^{1/3}$). The transducers were individually calibrated prior to each test series with quasistatic pressure pulses, using a standard solenoid-actuated air pressure calibration fixture adjusted to

Table 1. Transducer Calibration and Placement for M31A1E1 Slotted Stick Propellant

Channel number	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Expected pressure kPa (psi)	Calibration pressure kPa (psi)	100% Over calibration pressure kPa (psi)	Radial distance m (ft) Charge weight 27.22 kg (60 lb)	Radial distance m (ft) Charge weight 54.43 kg (120 lb)
1,2	1.19 (3)	922 (133.71)	2068.5 (300)	4137.4 (600)	3.68 (11.74)	4.51 (14.80)
3,4	1.59 (4)	479.8 (69.58)	1034.3 (150)	2068.5 (300)	4.77 (15.66)	6.01 (19.73)
5,6	2.14 (5.4)	242.5 (35.17)	517.2 (75)	1034.3 (150)	6.44 (21.14)	8.12 (26.64
7,8	3.57 (9)	81.5 (11.82)	103.4 (15)	206.9 (30)	10.74 (35.23)	13.53 (44.39)
9,10	7.14 (18)	24.07 (3.49)	34.5 (5)	69.0 (10)	21.48 (70.47)	27.06 (88.78)
11,12	15.9 (40)	8.14 (1.18)	13.8 (2)	27.6 (4)	47.73 (156.59)	60.14 (197.30)

correspond to expected overpressure based on an assumed TNT equivalency of 100 percent. Signal line continuity and channelization were checked prior to each test. Details of distances between charge and transducers, calibration pressures, and expected peak overpressures at each distance are shown in table 1.

Signals were recorded using six two-channel and two four-channel Nicolet Explorer digital oscilloscopes. A complete description of the recording system is given in Appendix A. These digital oscilloscopes offer the ability to capture, store, and display one-shot transient signals with both pre- and post-trigger information. Ionization probes were used to trigger the Nicolets and get T_o for time of arrival data.

Before and after color still photographs were taken of each test, showing typical setup and results. Standard meteorological data were recorded for each test. Video coverage of each test was also recorded.

RESULTS

Data Analysis

Peak overpressure and positive impulse information were acquired in digital form. Data that could be attributed to instrumentation or explosive malfunction were excluded. The mean and standard deviation were then obtained and all data which fell outside two standard deviations were excluded from the TNT equivalency calculations. The data were then compared with data from TNT hemispheres.[1] A computer program was employed which utilized an iterative process that factors out the contribution of the booster charge weight and calculates the pressure and impulse equivalencies.[2] The calculated TNT equivalencies were arranged in tabular form and plotted as functions of sample scaled distance. The standard curve for TNT hemisphere reference data is shown in Figure 3.

Test Results

A description of the instrumentation system is given in Appendix A. Data sheets for all tests with pertinent measured parameters are in Appendix B. Selected pretest and posttest still photographs are shown in Appendix C. Test numbers are shown for local reference only and provide access to original range data files.

Mean pressure, scaled positive impulse, and TNT equivalency data are summarized by test configurations in tables 2 through 7. Figures 4, 6, 8, 10, 12 and 14 show the plots of peak pressure and scaled positive impulse versus scaled distance. Figures 5, 7, 9, 11, 13, and 15 show the plots of TNT equivalency versus scaled distance for peak pressure and scaled positive impulse by test configuration.

Discussion

Plots of peak pressure and scaled positive impulse for the simulated fiberboard carton with a charge weight of 27.22-kg (60-lb) are shown in figures 4, 6, and 8. The plots of TNT equivalencies for pressure and scaled positive impulse are shown in figures 5, 7 and 9. The physical characteristics of the M31A1E1 slotted stick propellent and the geometric configuration of the fiberboard carton produced an effect upon detonation that was significantly different for each gage line. As a result, the mean values were not indicative of a maximum output for a prediction of blast parameters. Consequently, the results for the average values and each gage line are presented.

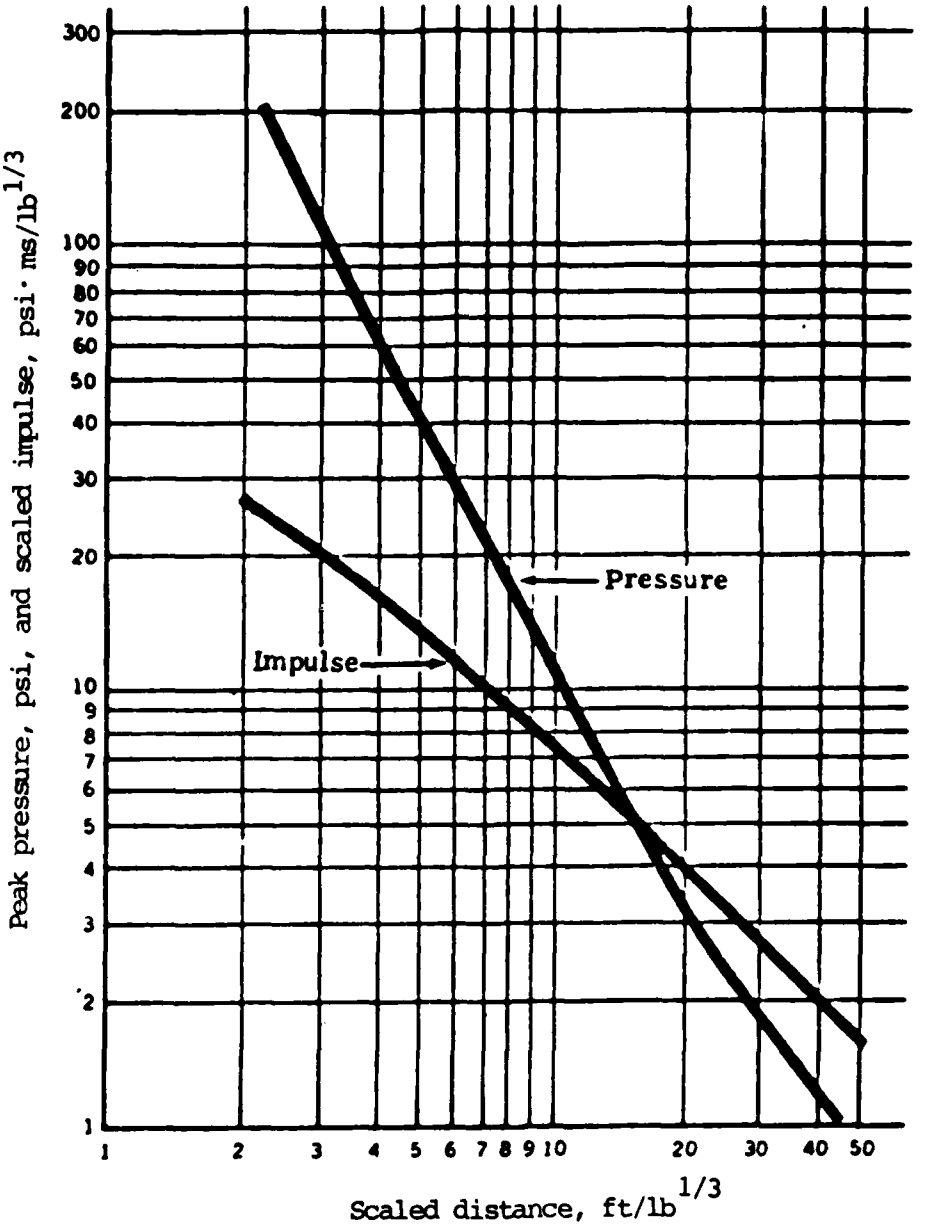


Figure 3. TNT Hemisphere Reference Data

As expected the blast effects produced along the short side of the box are significantly lower than the blast effects produced along the long side of the box. In general the effects are more pronounced for the near field values than for the far field values. Blast effects along the short side of the box were less than expected. TNT equivalency values for pressure and scaled positive impulse at all scaled distances are less than 100 percent. Blast effects along the long side of the box were greater than expected at scaled distance $\leq$ 2.14 m/kg$^{1/3}$ (5.40 ft/lb$^{1/3}$) and less than expected at scaled distances $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$).

TNT equivalency values for pressure and scaled positive impulse were greater than 100 percent at scaled distances $\leq$ 2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$) and less than 100 percent at scaled distances $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$). Average values are much higher than was measured along the short side of the box and much lower than was measured along the long side of the box at near field scaled distances $\leq$ 2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$). Values at the far field scaled distances $\geq$3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$) are more consistent and no real significant difference was measured.

Plots of peak pressure and scaled positive impulse for the simulated shipping/storage container with a charge weight of 54.43 kg (120 lb) are shown in figures 10, 12 and 14. The plots of TNT equivalencies for pressure and scaled positive impulse are shown in figures 11, 13, and 15. The results of the average values and each gage line are presented. As expected, the results produced along the short side of the box are lower than the results produced along the long side of the box. In general, the effects are more closely related for the far field scaled distances than for the near field scaled distance. Blast effects along the short side of the box were less than expected except at the close-in scaled distance of 1.19 m/kg$^{1/3}$ (3.0 ft/lb$^{1/3}$) where the TNT equivalency values for pressure and scaled positive impulse were greater than 100 percent.

Blast effects along the long side of the box were greater than expected for close-in scaled distances $\leq$ 2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$) and less than expected for far field scaled distances $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$). Average values for pressure equivalency were greater than 100 percent at the near field scaled distances $\leq$ 2.14 m/kg$^{1/3}$) (5.4 ft/lb$^{1/3}$) and less than 100 percent at the far field scaled distances $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$). TNT equivalency for scaled positive impulse was greater than 100 percent at the close in scaled distance of 1.19 m/kg$^{1/3}$ (3.0 ft/lb$^{1/3}$) and less than 100 percent at all other scaled distances.

Plots of peak pressure and scaled positive impulse for the 27.22-kg (60-lb) charge and the 54.43-kg (120-lb) charge reflect the geometric configuration from which they were detonated. As a result, the fiberboard carton which contained a 27.22-kg (60-lb) charge upon detonation produced significantly different results for the gage lines facing the short and long sides of the carton. For the 54.43-kg (120-lb) charge, the extent of the differences was much less for the long and short sides of the wooden container.

All information presented in this report is based on experimental data. As with any result based on experimental data, there is an inherent scatter involved; that is, the curves and tables presented represent the "best fit" or average values of the data, with some associated error band.

Table 2. Summary of Test Results, of Simulated Fiberboard Carton with a 27.22-kg (60 lb) Charge Weight (Average)

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Peak pressure kPa (psi)	Scaled positive impulse kpa $ms/kg^{1/3}$ (psi $ms/lb^{1/3}$)	Pressure TNT equivalency (%)	Impulse TNT equivalency (%)
3.58 (11.74)	1.19 (3.0)	1549.7 (224.75)	189.7 (21.14)	214	126
4.77 (15.66)	1.59 (4.0)	666.3 (96.64)	124.7 (13.90)	159	94
6.44 (21.14)	2.14 (5.4)	346.1 (50.19)	114.0 (12.70)	164	122
10.74 (35.23)	3.57 (9.0)	77.4 (11.23)	56.7 (6.32)	87	72
21.48 (70.47)	7.14 (18.0)	20.9 (3.03)	22.5 (2.51)	69	44
47.73 (156.59)	15.87 (40.0)	5.5 (0.80)	10.1 (1.12)	38	41

Table 3. Summary of Test Results of Simulated Fiberboard Carton with a 27.22-kg (60 lb) Charge Weight (Short Side of Box)

Radius meters (ft)/	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Peak pressure kPa (psi)	Scaled positive impulse kpa $ms/kg^{1/3}$ (psi $ms/lb^{1/3}$)	Pressure TNT equivalency %	Impulse TNT equivalency %
3.58 11.74	1.19 (3.0)	692.9 (100.50)	111.7 (12.45)	61	47
4.77 (15.66)	1.59 (4.0)	305.0 (44.23)	65.4 (7.29)	45	26
6.44 (21.14)	2.14 (5.4)	138.3 (20.06)	62.6 (6.98)	37	38
10.74 (35.23)	3.57 (9.0)	77.0 (11.17)	49.5 (5.52)	86	54
21.48 (70.47)	7.14 (18.0)	22.8 (3.30)	22.2 (2.47)	86	43
47.73 (156.59)	15.87 (40.0)	5.9 (0.85)	9.2 (1.03)	46	37

Table 4. Summary of Test Results, of Simulated Fiberboard Carton with a 27.22-kg (60 lb) Charge Weight (Long Side of Box)

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Peak pressure kPa (psi)	Scaled positive impulse kpa $ms/kg^{1/3}$ ($psi\ ms/lb^{1/3}$)	Pressure TNT equivalency %	Impulse TNT equivalency %
3.58 (11.74)	1.19 (3.0)	2406.3 (348.99)	267.8 (29.84)	368	206
4.77 (15.66)	1.59 (4.0)	1027.7 (149.05)	184.1 (20.52)	272	161
6.44 (21.14)	2.14 (5.4)	553.9 (80.33)	165.3 (18.42)	291	206
10.74 (35.23)	3.57 (9.0)	77.9 (11.30)	63.9 (7.12)	87	90
21.48 (70.47)	7.14 (18.0)	19.0 (2.76)	22.9 (2.55)	53	45
47.73 (156.59)	15.87 (40.0)	5.2 (0.76)	10.8 (1.20)	30	45

Table 5. Summary of Test Results of Simulated Wooden Shipping/ Storage Container with a 54.43-kg (120 lb) Charge Weight (Average)

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Peak pressure kPa (psi)	Scaled positive impulse kpa $ms/kg^{1/3}$ ($psi\ ms/lb^{1/3}$)	Pressure TNT equivalency %	Impulse TNT equivalency %
4.51 (14.80)	1.19 (3.0)	1323.2 (191.91)	224.4 (25.00)	157	159
6.01 (19.73)	1.59 (4.0)	635.9 (92.22)	106.3 (11.85)	138	65
8.12 (26.64)	2.14 (5.4)	301.2 (43.68)	79.2 (8.82)	125	60
13.53 (44.39)	3.57 (9.0)	61.4 (8.91)	53.6 (5.97)	54	52
27.06 (88.78)	7.14 (18.0)	19.5 (2.83)	25.7 (2.86)	62	52
60.14 (197.30)	15.87 (40.0)	7.0 (1.01)	13.8 (1.54)	64	66

Table 6. Summary of Test Results, of Simulated Wooden Shipping/ Storage Container with a 54.43-kg (120 lb) Charge Weight (Short Side of Box)

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Peak pressure kPa (psi)	Scaled positive impulse kpa $ms/kg^{1/3}$ (psi $ms/lb^{1/3}$)	Pressure TNT equivalency	Impulse TNT equivalency
				%	%
4.51 (14.80)	1.19 (3.0)	1220.4 (177.00)	213.5 (23.79)	139	141
6.01 (19.73)	1.59 (4.0)	504.8 (73.21)	85.8 (9.56)	97	48
8.12 (26.64)	2.14 (5.4)	220.2 (31.94)	61.6 (6.86)	76	37
13.53 (44.39)	3.57 (9.0)	58.9 (8.54)	47.7 (5.32)	50	53
27.06 (88.78)	7.14 (18.0)	19.9 (2.88)	22.0 (2.45)	65	42
60.14 (197.30)	15.87 (40.0)	8.0 (1.16)	15.6 (1.74)	86	81

Table 7. Summary of Test Results of Simulated Wooden Shipping/ Storage Container with a 54.43-kg (120 lb) Charge Weight (Long Side of Box)

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Peak pressure kPa (psi)	Scaled positive impulse kpa $ms/kg^{1/3}$ (psi $ms/lb^{1/3}$)	Pressure TNT equivalency	Impulse TNT equivalency
				%	%
4.51 (14.80)	1.19 (3.0)	1426.0 (206.82)	235.3 (26.22)	175	179
6.01 (19.73)	1.59 (4.0)	766.9 (111.22)	126.8 (14.13)	179	88
8.12 (26.64)	2.14 (5.4)	382.1 (55.41)	96.7 (10.78)	174	83
13.53 (44.39)	3.57 (9.0)	64.0 (9.28)	59.4 (6.62)	59	74
27.06 (88.78)	7.14 (18.0)	19.4 (2.81)	27.6 (3.07)	59	58
60.14 (197.30)	15.87 (40.0)	6.0 (0.87)	12.0 (1.34)	43	52

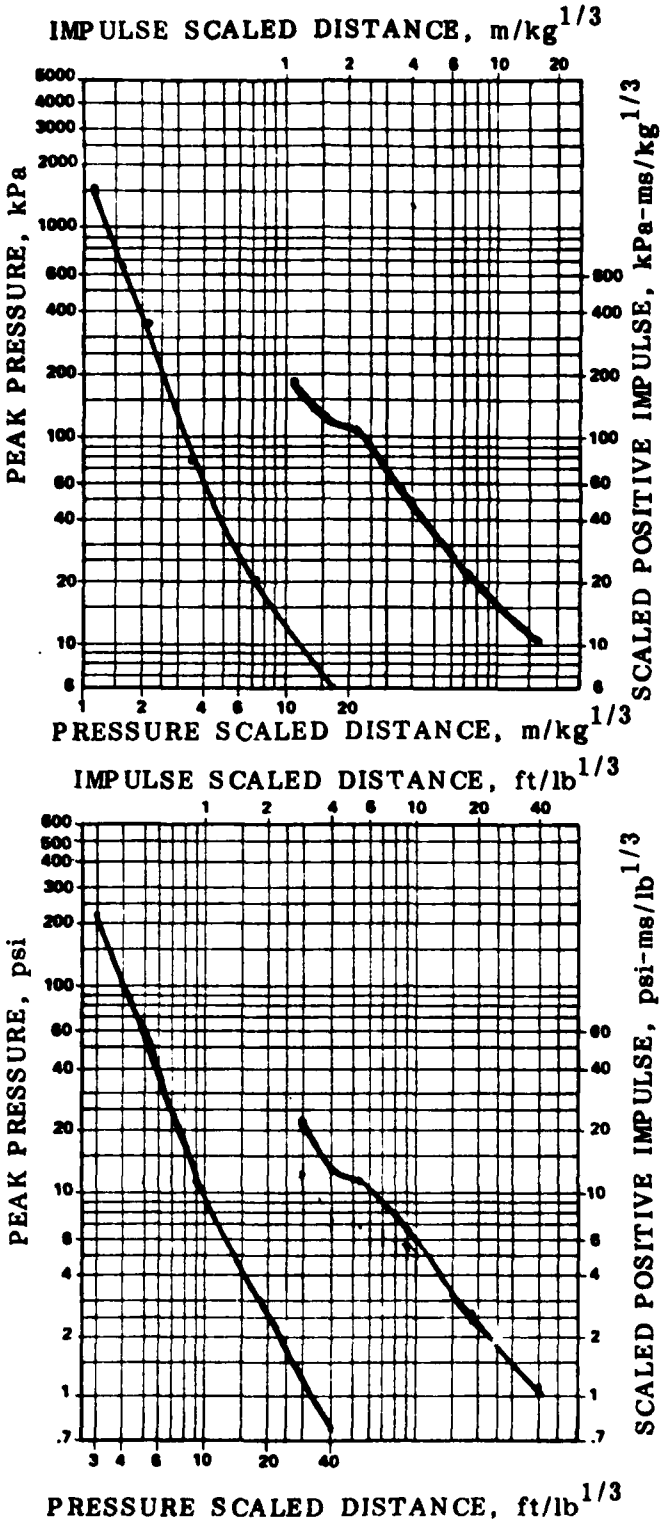


Figure 4. Pressure and Scaled Positive Impulse versus Scaled Distance for Simulated Fiberboard Carton with 27.22-kg (60-lb) Charge Weight (Average)

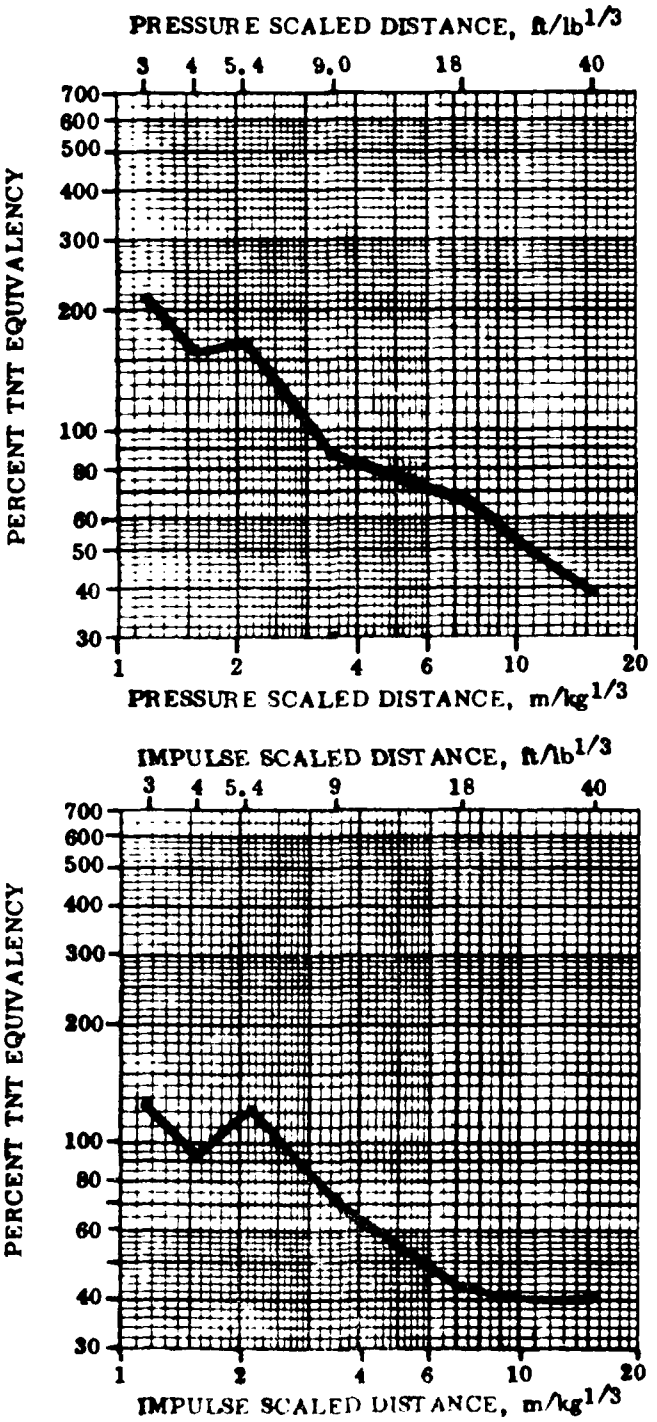


Figure 5. Pressure and Scaled Positive Impulse TNT Equivalency for Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight (Average)

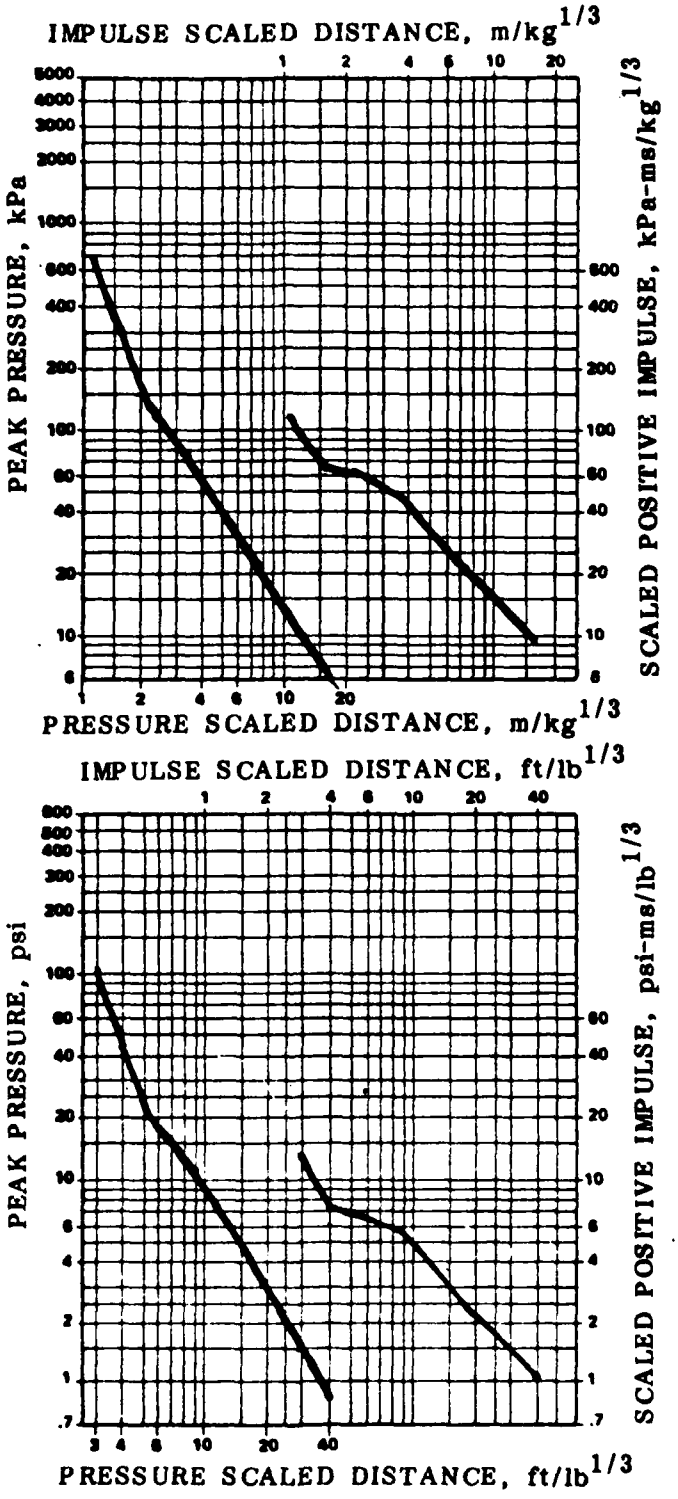


Figure 6. Pressure and Scaled Positive Impulse Versus Scaled Distance for Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight (Short Side of Box)

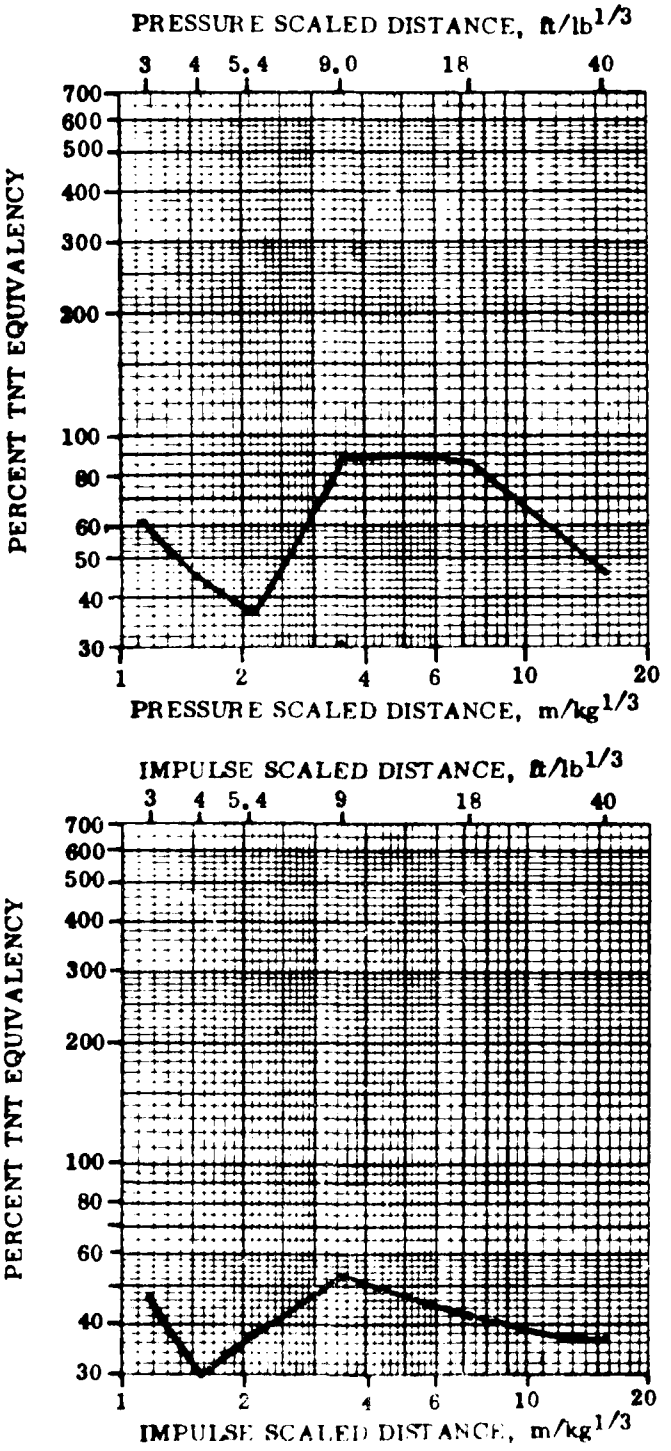


Figure 7. Pressure and Scaled Positive Impulse TNT Equivalency for Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight (Short Side of Box)

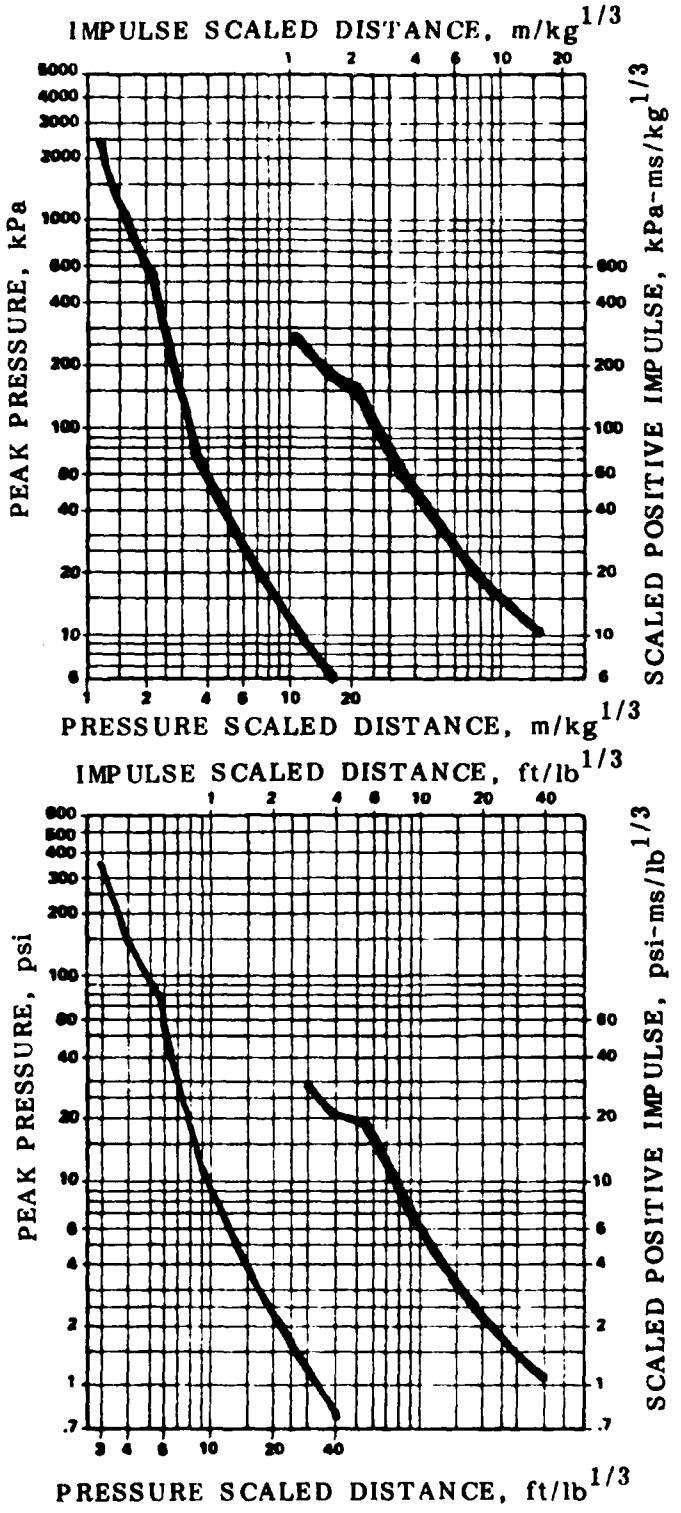


Figure 8. Pressure and Scaled Positive Impulse Versus Scaled Distance for Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight (Long Side of Box)

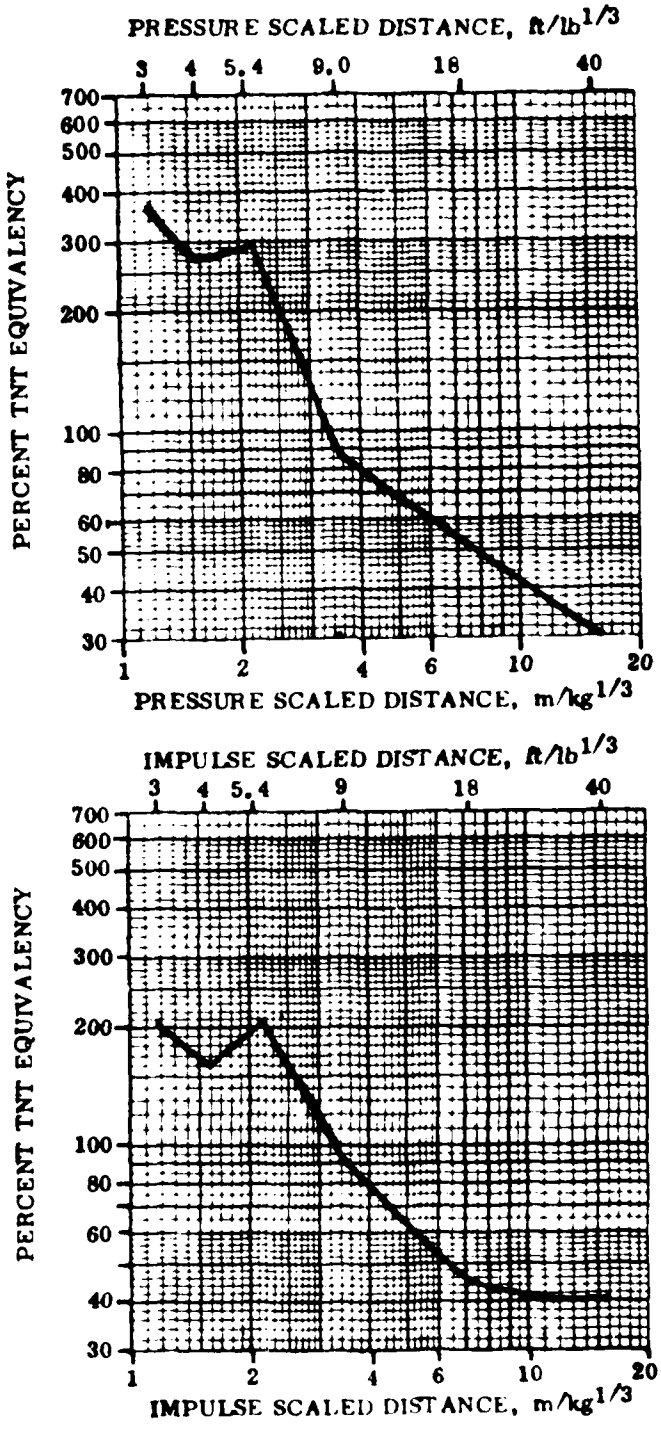


Figure 9. Pressure and Scaled Positive Impulse TNT Equivalency for Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight (Long Side of Box)

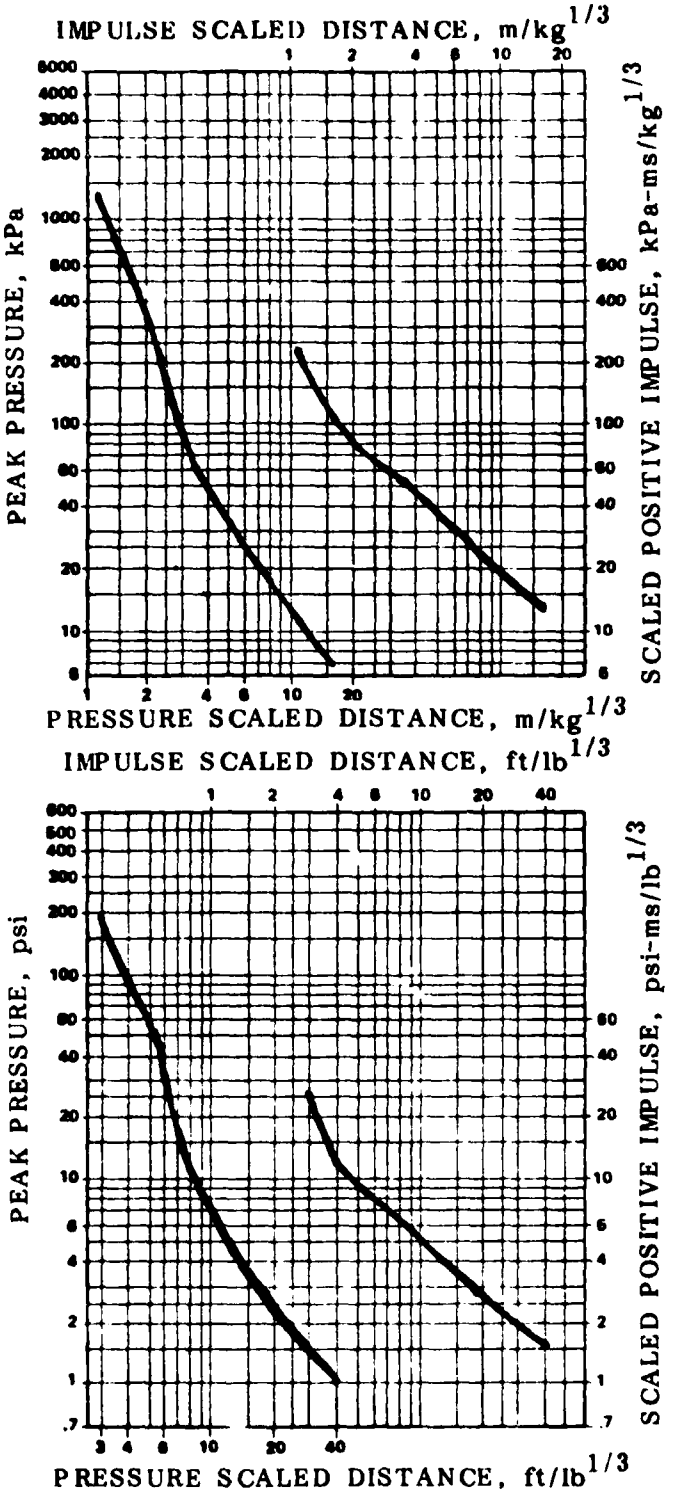


Figure 10. Pressure and Scaled Positive Impulse Versus Scaled Distance for Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight (Average)

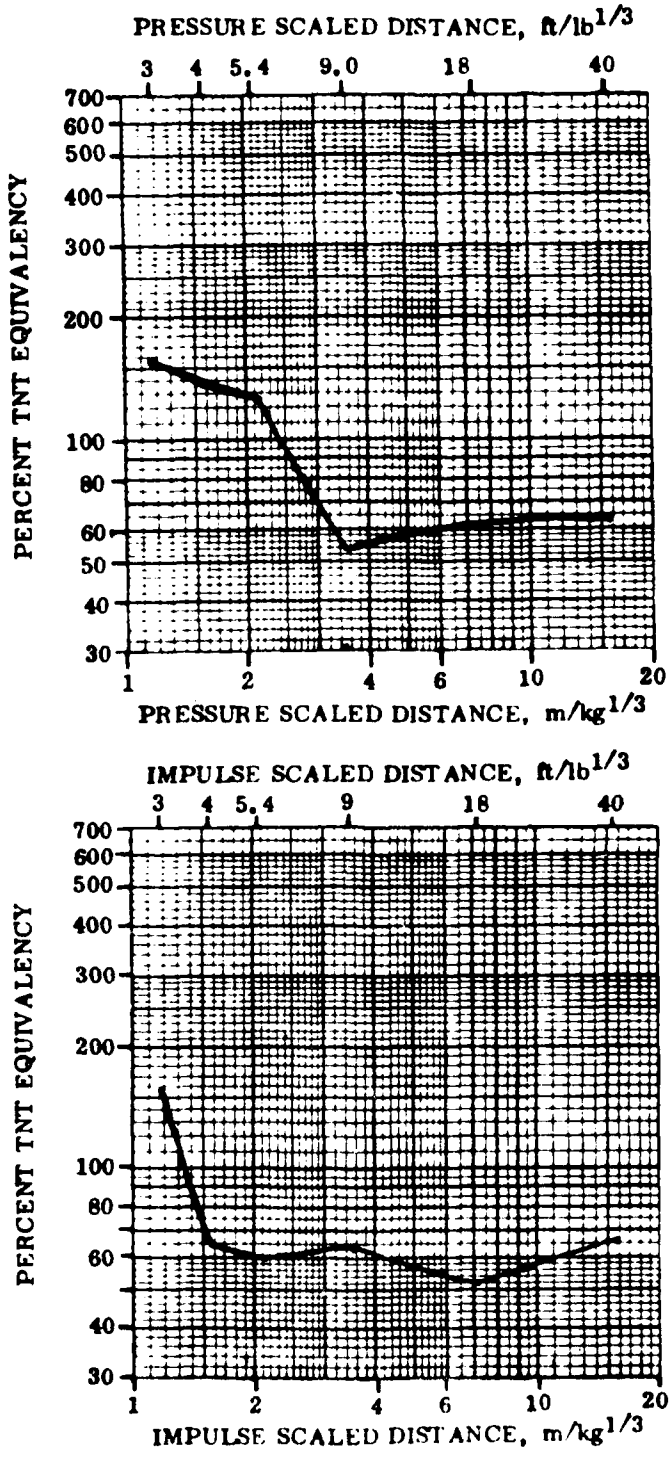


Figure 11. Pressure and Scaled Positive Impulse TNT Equivalency for a Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight (Average)

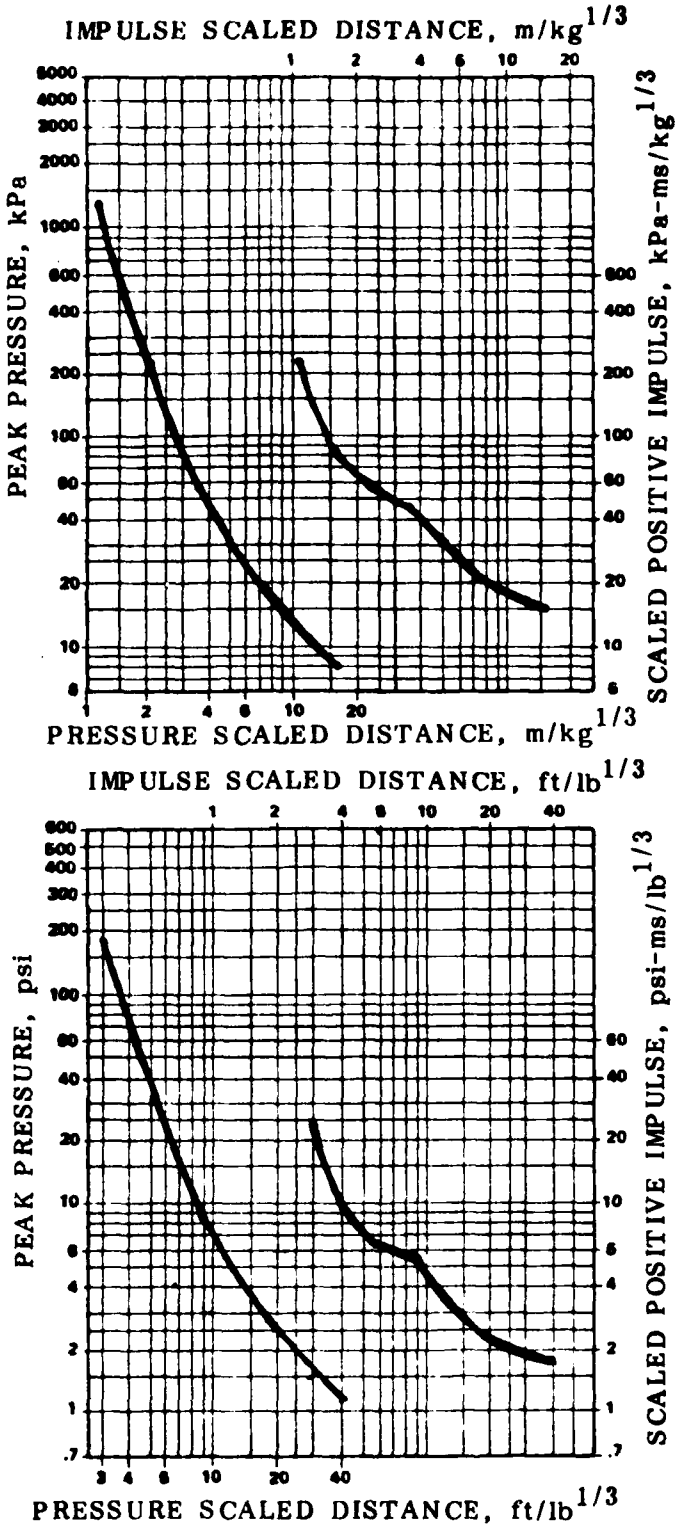


Figure 12. Pressure and Scaled Positive Impulse Versus Scaled Distance for Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight (Short Side of Box)

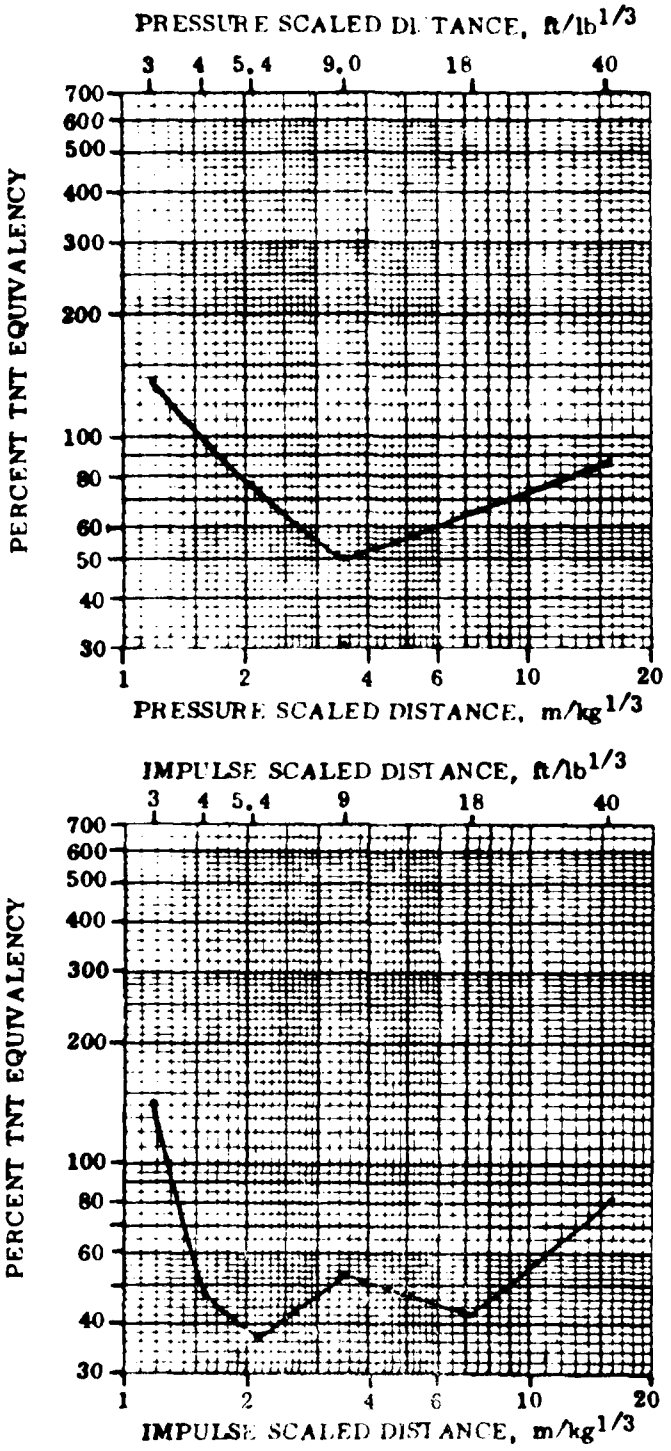


Figure 13. Pressure and Scaled Positive Impulse TNT Equivalency for a Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight (Short Side of Box)

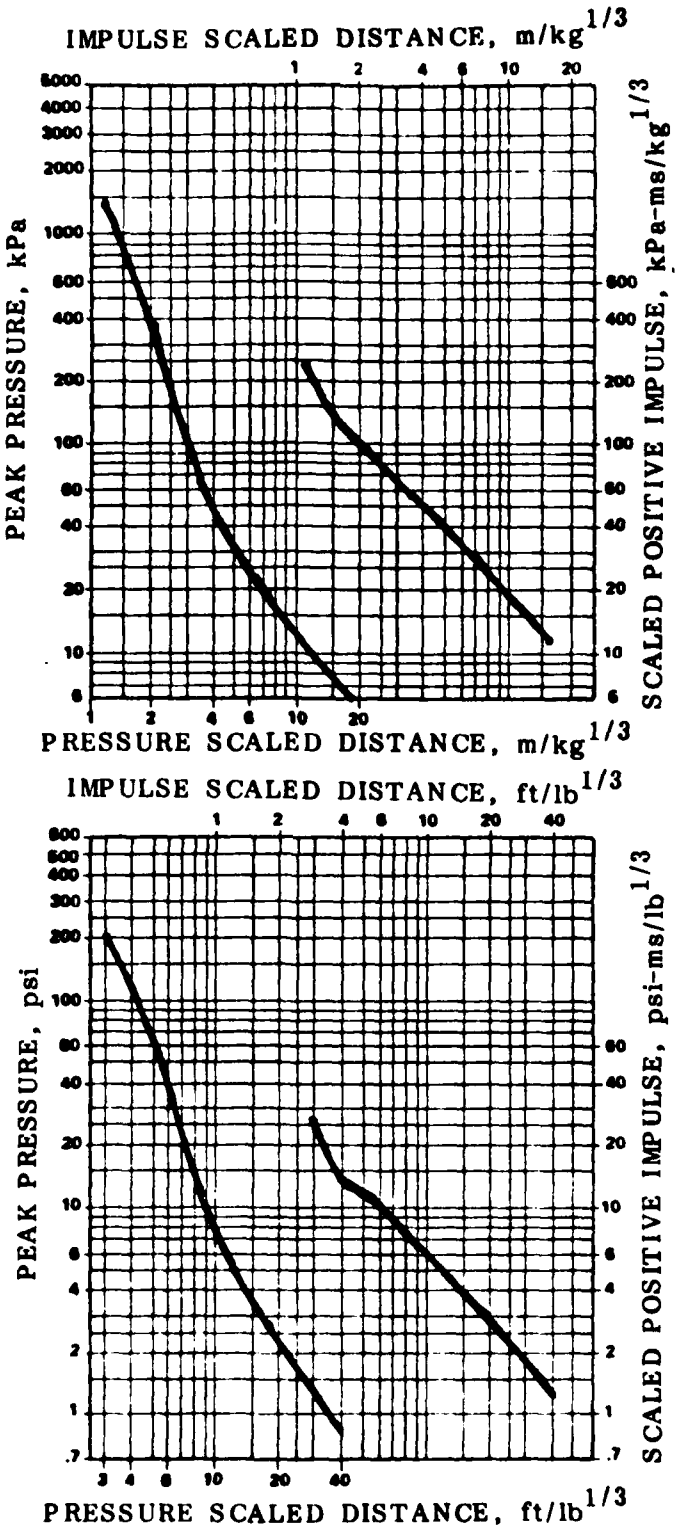


Figure 14. Pressure and Scaled Positive Impulse Versus Scaled Distance for Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight (Long Side of Box)

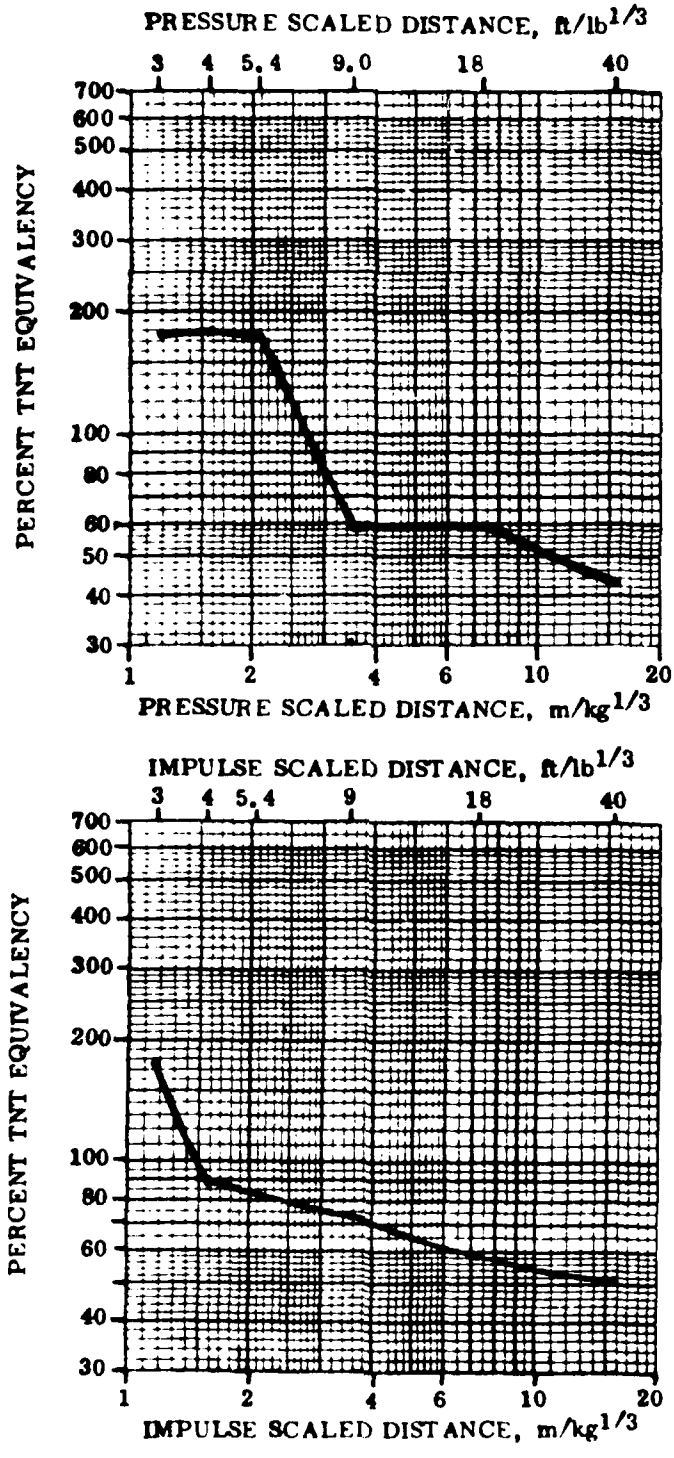


Figure 15. Pressure and Scaled Positive Impulse TNT Equivalency for Simulated Wooden Shipping/Storage with a 54.43-kg (120-lb) Charge Weight (Long Side of Box)

CONCLUSIONS

1. The blast output from M31A1E1 slotted stick propellant is dependent upon the configuration from which it detonates.

2. TNT equivalency values were determined from M31A1E1 slotted stick propellant in configurations that simulated a single fiberboard carton and a wooden box that simulated the shipping/storage container.

3. The TNT equivalency of M31A1E1 slotted stick propellant for peak pressure as determined in this test series ranged from a high of 368 percent along the long side to a low of 37 percent along the short side for the simulated fiberboard carton. Peak pressures ranged from a high of 179 percent along the long side to a low of 50 percent along the short side for the simulated wooden box.

RECOMMENDATIONS

1. In order to design meaningful experiments and for the resulting data to be intelligently applied, it is important that the many factors and parameters that affect the airblast be recognized and the data be used in the context in which they were derived.

2. The TNT equivalency of pressure and scaled positive impulse values determined by this test series should be used in the structural design of protective facilities.

3. M31A1E1 slotted stick propellant should be tested in the configurations that are typical for a manufacturing facility.

4. For close-in structural design (scaled distances generally less than 3.0 $ft/lb^{1/3}$), values generated by this test program should not be used. A method for determining the TNT spherical equivalent weight is to multiply the charge weight by an equivalency from the ratios of the heats of detonation. Then a factor must be determined for the effect of charge shape. Some sources for this data are in references 4 and 5.

REFERENCES

1. Kingery, C. N. Airblast Parameters Versus Distance for Hemispherical TNT Surface Bursts, BRL Report No. 1344. September 1966.

2. McKown, G. L. TNT Equivalency of R284, I559, and I560 Tracer Composition. October 1978.

3. Hopkinson, B. 1915 British Ordnance Board Minutes 13565.

4. Wisotski, John, and Snyer, W. H. "Characteristics of Blast Waves Obtained from Cyclindrical high Explosive Charges," Denver Research Institute. November 1965.

5. Plooster, M. N. "Blast Front Pressure from Cylindrical Charges of High Explosives," Naval Weapons Center Technical Memorandum No. 3631, Navy Contract No. N00123-76-C-0166, Denver Research Institute. September 1978.

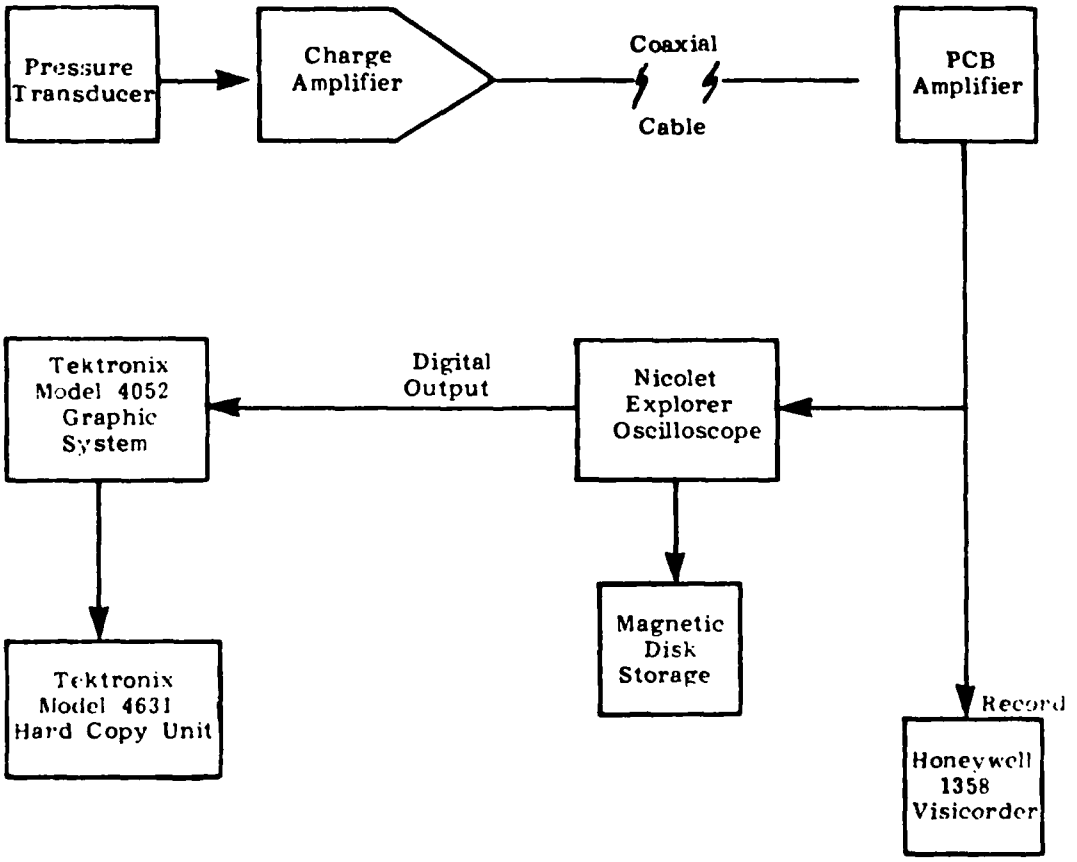
APPENDIX A

INSTRUMENTATION

APPENDIX A

INSTRUMENTATION

Twelve PCB Piezotronics side-on pressure transducers were mounted flush to the surface in each of two sand-filled arrays within the test area. Each transducer was connected by an underground coaxial cable system into the instrumentation building approximately 800 feet from the test area. All signals were amplified by a model 494A06 PCB amplifier and recorded simultaneously on dual channel Nicolet Explorer oscilloscopes and a Honeywell 1858 visicorder. The Nicolet Explorer oscilloscopes were chosen because of their performance; they also provide a wide choice of options and measurement capabilities. It is basically a two-channel, 500-kHz oscilloscope having a writing rate of 5 cm/ sec, rise time of 500 ns and high resolution. It is useful in transducer measurements in providing direct electrical signal measurements, and with the built-in magnetic disk recorder, has the capability of storing signal waveforms for quick and easy recall. The Nicolet Explorer oscilloscopes were interfaced to a Tektronix 4052 graphic system and the peak blast overpressure and positive impulse information were obtained in digital form. The Honeywell 1858 visicorder was operated at 160 inches per second along with a 1 kHz timing pulse.



APPENDIX B

DATA SHEETS

TEST TITLE TNT EQUIVALENCY DATE 28 Feb 85

TEST SAMPLE M31A1E1 Propellant TIME 1157

SAMPLE WEIGHT 27.22 kg (60 lb) TEMP. 58° F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 42%

BOOSTER WT. 1.36 kg (3.0 lb) BAR. PRESS. 30.22

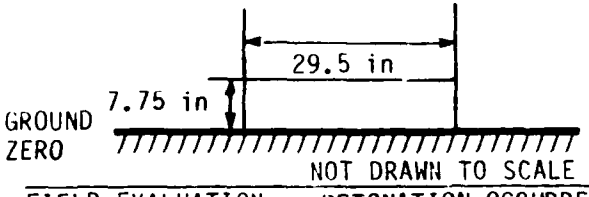
TEST NO. 9-85-02 WIND DIR. NW

CONTRACT NO. NAS 13-50 WIND VEL. 6K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 3.81

INITIATOR
J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.58	--	--	--
2	(11.74)	--	--	--
3	4.77	--	--	--
4	(15.66)	--	--	--
5	6.44	--	--	--
6	(21.14)	--	--	--
7	10.74	79.57 (11.54)	48.19 (5.37)	10.72
8	(35.23)	75.98 (11.02)	52.95 (5.90)	5.56
9	21.48	24.34 (3.53)	28.45 (3.17)	39.0
10	(70.47)	18.55 (2.69)	23.96 (2.67)	33.4
11	47.73	3.59 (0.52)	19.41 (1.16)	112.6
12	(156.59)	3.72 (0.54)	9.96 (1.11)	107.2

TEST TITLE TNT EQUIVALENCY DATE 28 FEB 1985

TEST SAMPLE M31A1E1 PROPELLANT TIME 1400

SAMPLE WEIGHT 27.22 kg (60 lb) TEMP. 66°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 33%

BOOSTER WT. 1.36 kg (3.0 lb) BAR. PRESS. 30.22

TEST NO. 9-85-03 WIND DIR. NW

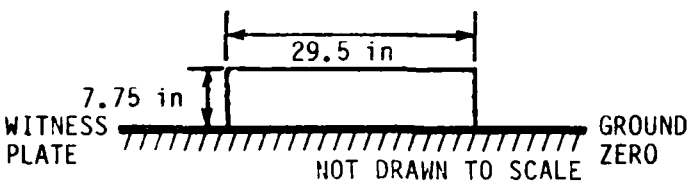
CONTRACT NO. NAS 13-50 WIND VEL. 6K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 3.81

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.58	496.44 (72.00)	84.45 (9.41)	2.07
2	(11.74)	2275.35 (330.00)	254.59 (28.37)	1.22
3	4.77	242.08 (35.11)	62.55 (6.97)	4.11
4	(15.66)	1101.41 (159.74)	187.83 (20.93)	2.17
5	6.44	108.25 (15.70)	53.22 (5.93)	7.64
6	(21.14)	557.18 (80.81)	138.65 (15.45)	4.44
7	10.74	75.29 (10.92)	49.54 (5.52)	18.06
8	(35.23)	75.98 (11.02)	39.04 (4.35)	12.40
9	21.48	21.93 (3.18)	13.19 (1.47)	46.20
10	(70.47)	17.93 (2.60)	22.88 (2.55)	40.25
11	47.73	6.27 (0.91)	9.42 (1.05)	119.00
12	(156.59)	5.93 (0.86)	10.59 (1.18)	114.00

TEST TITLE TNT EQUIVALENCY DATE 28 FEB 85

TEST SAMPLE M31A1E1 PROPELLANT TIME 1453

SAMPLE WEIGHT 27.22 kg (60 lb) TEMP. 66°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 38%

BOOSTER WT. 1.36 kg (3.75 lb) BAR. PRESS. 30.22

TEST NO. 9-85-04 WIND DIR. NW

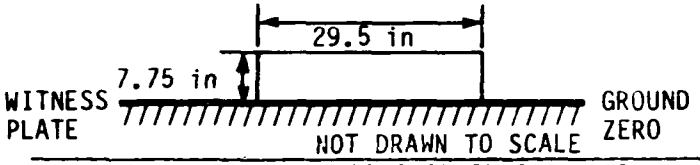
CONTRACT NO. NAS 13-50 WIND VEL. 4K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 3.81

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE METERS (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.58	868.77 (126.00)	90.55 (10.09)	2.13
2	(11.74)	1737.54 (252.00)	227.49 (25.35)	1.41
3	4.77	374.12 (54.26)	66.14 (7.37)	3.96
4	(15.66)	1101.41 (159.74)	175.53 (19.56)	2.31
5	6.44	108.25 (15.70)	62.73 (6.99)	7.44
6	(21.14)	464.31 (67.34)	160.81 (17.92)	4.36
7	10.74	81.77 (11.86)	49.36 (5.50)	18.18
8	(35.23)	65.43 (9.49)	47.38 (5.28)	13.08
9	21.48	23.72 (3.44)	31.95 (3.56)	46.20
10	(70.47)	18.55 (2.69)	35.00 (3.90)	41.10
11	47.73	3.59 (0.52)	7.81 (0.87)	119.00
12	(156.59)	3.72 (0.54)	13.64 (1.52)	114.60

TEST TITLE TNT EQUIVALENCY DATE 7 MAR 1985

TEST SAMPLE M31A1E1 PROPELLANT TIME 1334

SAMPLE WEIGHT 27.22 kg (60 lb) TEMP. 72°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 50%

BOOSTER WT. 2.72 kg (6.0 lb) BAR. PRESS. 30.30

TEST NO. 10-85-08 WIND DIR. SSE

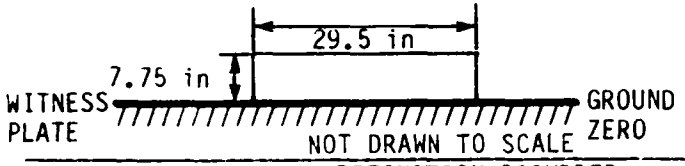
CONTRACT NO. NAS 13-50 WIND VEL. 2K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 3.81

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.58	620.55 (90.00)	155.43 (17.32)	2.39
2	(11.74)	2700.63 (391.68)	339.04 (37.78)	1.53
3	4.77	258.63 (37.51)	61.02 (6.80)	4.19
4	(15.66)	873.53 (126.69)	188.27 (20.98)	2.54
5	6.44	156.31 (22.67)	69.46 (7.74)	7.46
6	(21.14)	530.64 (76.96)	161.98 (18.05)	4.60
7	10.74	69.71 (10.11)	51.15 (5.70)	17.60
8	(35.23)	92.67 (13.44)	103.47 (11.53)	12.70
9	21.48	21.72 (3.15)	19.65 (2.19)	45.05
10	(70.47)	21.44 (3.11)	11.04 (1.23)	40.60
11	47.73	7.93 (1.15)	3.95 (6.44)	117.4
12	(156.59)	6.69 (0.97)	9.78 (1.09)	115.2

TEST TITLE TNT EQUIVALENCY DATE 7 Mar 1985

TEST SAMPLE M31A1E1 PROPELLANT TIME 1507

SAMPLE WEIGHT 27.22 kg (60 lb) TEMP. 72°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 50%

BOOSTER WT. 2.72kg (6.0 lb) BAR. PRESS. 30.29

TEST NO. 10-85-09 WIND DIR. SSE

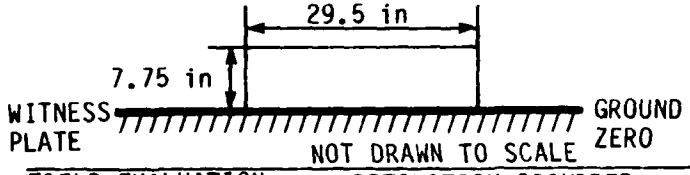
CONTRACT NO. NAS 13-50 WIND VEL. 3K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 3.81

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.58	786.03 (114.00)	116.39 (12.97)	2.42
2	(11.74)	2911.62 (422.28)	249.84 (27.84)	1.57
3	4.77	344.89 (50.02)	72.06 (8.03)	4.31
4	(15.66)	1346.37 (150.03)	184.86 (20.60)	2.52
5	6.44	180.37 (26.16)	65.06 (7.25)	7.72
6	(21.14)	663.30 (96.20)	199.67 (22.25)	4.56
7	10.74	78.67 (11.41)	49.27 (5.49)	17.68
8	(35.23)	79.43 (11.52)	76.82 (8.56)	12.90
9	21.48	22.34 (3.24)	17.41 (1.94)	44.90
10	(70.47)	18.55 (2.69)	21.36 (2.38)	39.80
11	47.73	7.93 (1.15)	14.63 (1.63)	117.20
$^{1}2$	(156.59)	6.07 (0.88)	10.05 (1.12)	113.60

TEST TITLE TNT EQUIVALENCY DATE 4 MAR 1985

TEST SAMPLE M31A1E1 PROPELLANT TIME 1158

SAMPLE WEIGHT 54.43 kg (120 lb) TEMP. 68°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 52%

BOOSTER WT. 2.72 kg (6.00 lb) BAR. PRESS. 29.90

TEST NO. 10-85-01 WIND DIR. SSE

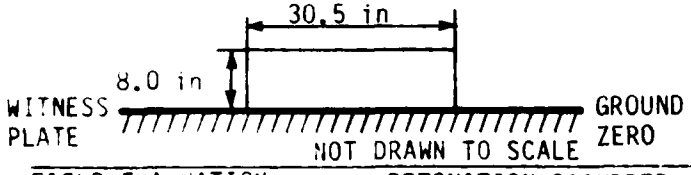
CONTRACT NO. NAS 13-50 WIND VEL. 2K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	910.14 (132.00)	235.03 (26.19)	2.19
2	(14.80)	1241.10 (180.00)	183.43 (20.44)	1.76
3	6.01	344.89 (50.02)	68.47 (7.63)	3.96
4	(19.73)	735.63 (106.69)	129.49 (14.43)	3.28
5	8.12	192.37 (27.90)	48.28 (5.38)	7.74
6	(26.64)	403.77 (58.56)	80.86 (9.01)	6.40
7	13.53	52.95 (7.68)	50.52 (5.63)	20.36
8	(44.39)	66.81 (9.69)	53.13 (5.92)	15.40
9	27.06	--	--	--
10	(88.78)	16.62 (2.41)	26.65 (12.97)	53.40
11	60.14	8.27 (1.20)	17.95 (2.00)	147.20
12	(197.30)	5.72 (0.83)	11.58 (1.29)	146.60

TEST TITLE TNT EQUIVALENCY DATE 4 Mar 1984

TEST SAMPLE M31A1E1 PROPELLANT TIME 1359

SAMPLE WEIGHT 54.43kg (120 lb) TEMP. 72°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 50%

BOOSTER WT. 2.72kg (6.0 lb) BAR. PRESS. 29.80

TEST NO. 10-85-02 WIND DIR. SSE

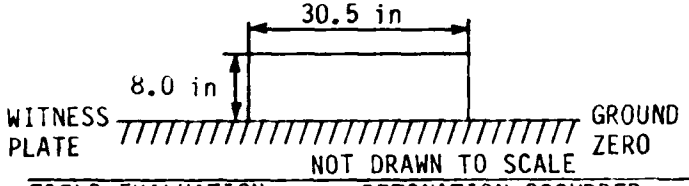
CONTRACT NO. NAS 13-50 WIND VEL. 2K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	1034.25 (150.00)	163.51 (18.22)	0.88
2	(14.80)	1323.84 (192.00)	141.97 (15.82)	0.57
3	6.01	538.84 (78.15)	86.33 (9.62)	2.71
4	(19.73)	620.69 (90.02)	129.67 (14.45)	2.10
5	8.12	240.50 (34.88)	56.00 (6.24)	6.02
6	(26.64)	189.27 (27.45)	71.07 (7.92)	5.34
7	13.53	50.68 (7.35)	54.38 (6.06)	18.42
8	(44.39)	64.47 (9.35)	48.37 (5.39)	17.38
9	27.06	--	--	--
10	(88.78)	17.24 (2.50)	25.58 (2.85)	52.20
11	60.14	7.58 (1.10)	12.74 (1.42)	146.00
12	(197.30)	6.07 (0.88)	12.20 (1.36)	145.00

TEST TITLE TNT EQUIVALENCY DATE 4 MAR 1985

TEST SAMPLE M31A1E1 PROPELLANT TIME 1536

SAMPLE WEIGHT 54.43 kg (120 lb) TEMP. 70°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 42%

BOOSTER WT. 5.44 kg (12 lb) BAR. PRESS. 29.80

TEST NO. 10-85-03 WIND DIR. SSE

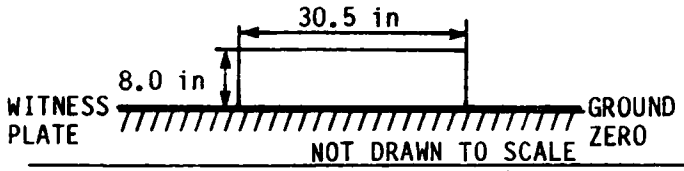
CONTRACT NO. NAS 13-50 WIND VEL. 4K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	1241.10 (180.00)	167.54 (18.67)	2.47
2	(14.80)	1530.69 (222.00)	200.84 (22.38)	1.83
3	6.01	560.43 (81.28)	102.39 (11.41)	4.24
4	(19.73)	988.47 (143.36)	147.35 (16.42)	3.25
5	8.12	264.56 (38.37)	64.70 (7.21)	7.52
6	(26.64)	466.86 (67.71)	93.87 (10.46)	6.00
7	13.53	62.19 (9.02)	67.57 (7.53)	19.56
8	(44.39)	62.19 (9.02)	69.01 (7.69)	16.96
9	27.06	--	--	--
10	(88.78)	17.86 (2.59)	28.90 (3.22)	51.90
11	60.14	8.96 (1.30)	18.04 (2.01)	145.80
1_2	(197.30)	6.41 (0.93)	13.82 (1.54)	143.40

TEST TITLE TNT EQUIVALENCY DATE 5 MAR 1985

TEST SAMPLE M31A1E1 PROPELLANT TIME 1127

SAMPLE WEIGHT 54.43 kg (120 lb) TEMP. 72°F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 42%

BOOSTER WT. 5.44 kg (12 lb) BAR. PRESS. SSE

TEST NO. 10-85-04 WIND DIR. 2K

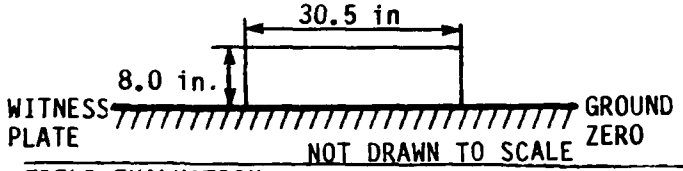
CONTRACT NO. NAS 13-50 WIND VEL. 30.20

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR

J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	1137.68 (165.00)	235.84 (26.28)	1.57
2	(14.80)	1226.90 (177.94)	226.50 (25.24)	1.46
3	6.01	472.86 (68.58)	54.65 (6.09)	3.08
4	(19.73)	714.74 (103.66)	97.46 (10.86)	2.92
5	8.12	206.85 (30.00)	51.06 (5.69)	6.24
6	(26.64)	330.96 (48.00)	94.77 (10.56)	5.70
7	13.53	56.81 (8.24)	42.00 (4.68)	18.42
8	(44.39)	58.75 (8.52)	52.86 (5.89)	16.98
9	27.06	--	--	
10	(88.78)	--	--	
11	60.14	--	--	
I_2	(197.30)	--	--	

TEST TITLE TNT EQUIVALENCY DATE 5 MAR 85

TEST SAMPLE M3A1E1 PROPELLANT TIME 1340

SAMPLE WEIGHT 54.43 kg (120lb) TEMP. 74° F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 4290%

BOOSTER WT. 5.44 kg (12 lb) BAR. PRESS. 30.20

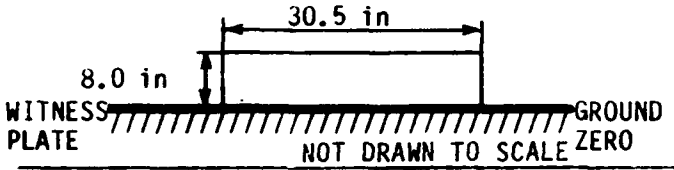
TEST NO. 10-85-05 WIND DIR. SSE

CONTRACT NO. NAS 13-50 WIND VEL. 4K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR
J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	1489.32 (216.00)	252.89 (28.18)	2.31
2	(14.80)	1944.39 (282.00)	245.26 (27.33)	2.06
3	6.01	625.03 (90.65)	102.48 (11.42)	3.78
4	(19.73)	944.06 (136.92)	150.14 (16.73)	3.42
5	8.12	276.56 (40.11)	78.07 (8.70)	6.70
6	(26.64)	541.81 (78.58)	135.33 (15.08)	5.96
7	13.53	55.30 (8.02)	51.96 (5.76)	18.90
8	(44.39)	75.98 (11.02)	58.24 (6.49)	16.78
9	27.06	18.89 (2.74)	31.95 (3.56)	54.90
10	(88.78)	23.03 (3.34)	26.92 (3.00)	51.35
11	60.14	7.58 (1.10)	14.27 (1.59)	146.60
12	(197.30)	5.52 (0.80)	11.04 (1.23)	143.20

TEST TITLE TNT EQUIVALENCY DATE 5 MAR 85

TEST SAMPLE M31A1E1 PROPELLANT TIME 1428

SAMPLE WEIGHT 54.43 kg (120lb) TEMP. 74° F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 40%

BOOSTER WT. 5.44 kg (12 lb) BAR. PRESS. 30.20

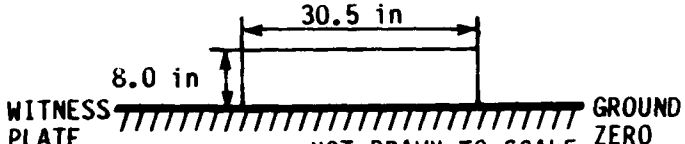
TEST NO. 10-85-06 WIND DIR. SSE

CONTRACT NO. NAS 13-50 WIND VEL. 2K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR
J-2 CAP



FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	1406.58 (204.00)	159.74 (17.80)	2.60
2	(14.80)	1365.21 (198.00)	192.76 (21.48)	2.52
3	6.01	474.17 (68.77)	90.73 (10.11)	4.30
4	(19.73)	651.85 (94.54)	114.33 (12.74)	4.17
5	8.12	228.50 (33.14)	64.88 (7.23)	7.66
6	(26.64)	357.09 (51.79)	97.28 (10.84)	7.24
7	13.53	64.47 (9.35)	48.55 (5.41)	19.88
8	(44.39)	64.47 (9.35)	60.40 (6.73)	18.70
9	27.06	20.34 (2.95)	22.26 (2.48)	55.40
10	(88.78)	21.41 (2.96)	28.27 (3.15)	53.35
11	60.14	6.83 (0.99)	13.73 (1.53)	147.40
12	(197.30)	5.79 (0.84)	10.68 (1.19)	145.20

TEST TITLE TNT EQUIVALENCY DATE 7 MAR 85

TEST SAMPLE M3A1E1 PROPELLANT TIME 1050

SAMPLE WEIGHT 54.43 kg (120lb) TEMP. 72° F

IGN. SOURCE J2 BLASTING CAP HUMIDITY 70%

BOOSTER WT. 5.44 kg (12 lb) BAR. PRESS. 30.30

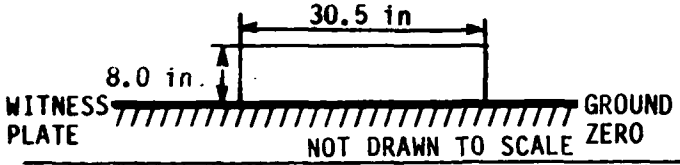
TEST NO. 10-85-07 WIND DIR. W

CONTRACT NO. NAS 13-50 WIND VEL. 2K

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 1.85

INITIATOR
J-2 CAP

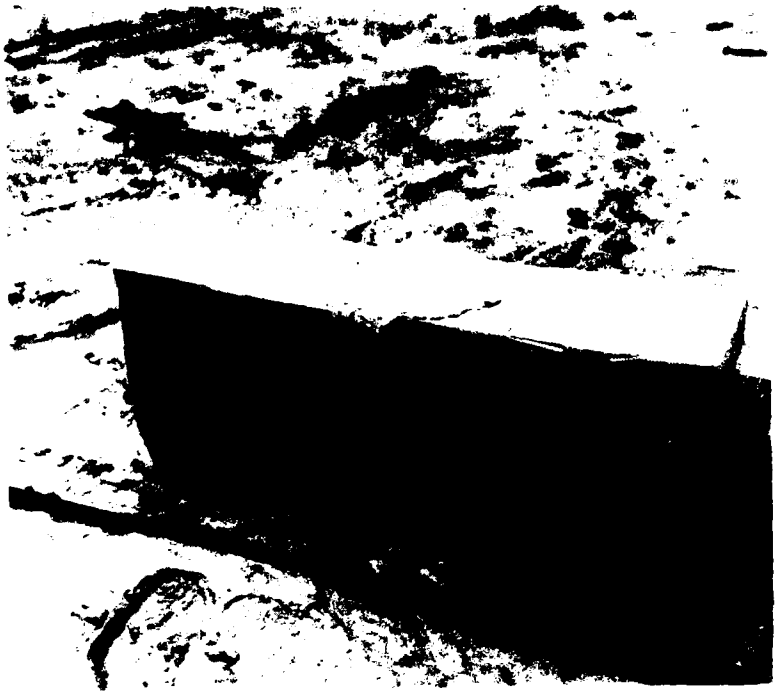


FIELD EVALUATION DETONATION OCCURRED:

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	4.51	1323.84 (192.00)	279.63 (31.16)	2.29
2	(14.80)	1365.32 (195.84)	456.33 (50.85)	2.12
3	6.01	517.26 (72.02)	95.75 (10.67)	4.02
4	(19.73)	712.60 (103.35)	119.08 (13.27)	3.34
5	8.12	132.25 (19.18)	67.75 (7.55)	7.26
6	(26.64)	384.74 (55.80)	104.10 (11.60)	6.12
7	13.53	69.71 (10.11)	19.38 (2.16)	20.02
8	(44.39)	55.16 (8.00)	74.13 (8.26)	17.70
9	27.06	20.34 (2.95)	11.76 (1.31)	55.05
10	(88.78)	20.96 (3.04)	28.90 (3.22)	52.95
11	60.14	8.83 (1.28)	16.69 (1.86)	145.80
12	(197.30)	6.27 (0.91)	12.65 (1.41)	145.40

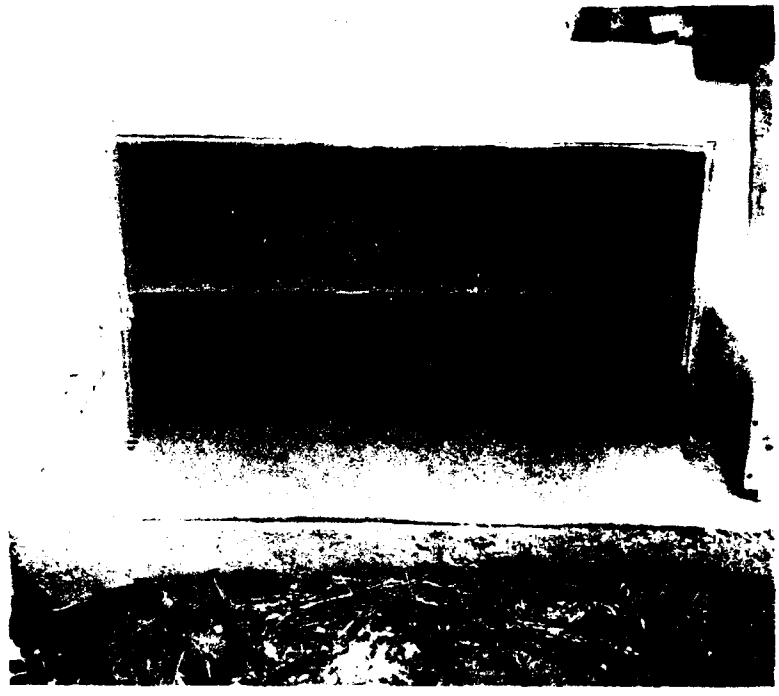
APPENDIX C

SELECTED PHOTOGRAPHS



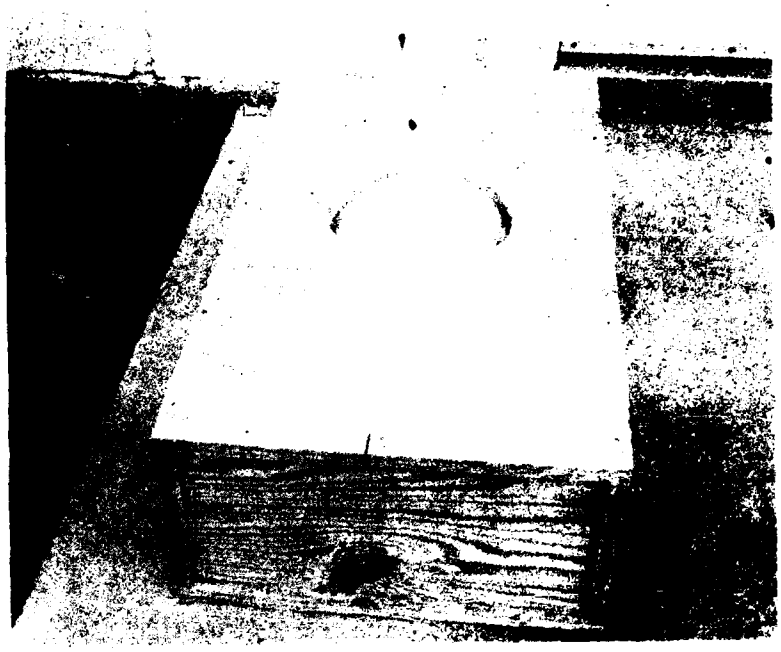
Test No. 9-85-01. Typical Pretest Configuration for TNT Equivalency Testing of M31A1E1 Slotted Stick Propellant in a Simulated Fiberboard Carton with a 27.22-kg (60-lb) Charge Weight

Test No. 9-85-01. Typical Posttest Results for TNT Equivalency Testing of M31A1E1 Slotted Stick Propellant in a Simulated Fiberboard Carton With a 27.22-kg (60-lb) With a 27.22-kg (60-lb) Charge Weight



Test No. 10-85-01. Pretest Configuration of Two Fiberboard Cartons in a Simulated Wooden Shipping/Storage Container

Test No. 10-85-01. Physical Characteristics of M31A1E1 Slotted Stick Propellant Packaged in Two Fiberboard Cartons in a Simulated Wooden Shipping/Storage Container



Test No. 10-85-01. Pretest Configuration for TNT Equivalency Testing of M31A1E1 Slotted Stick Propellant in a Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight

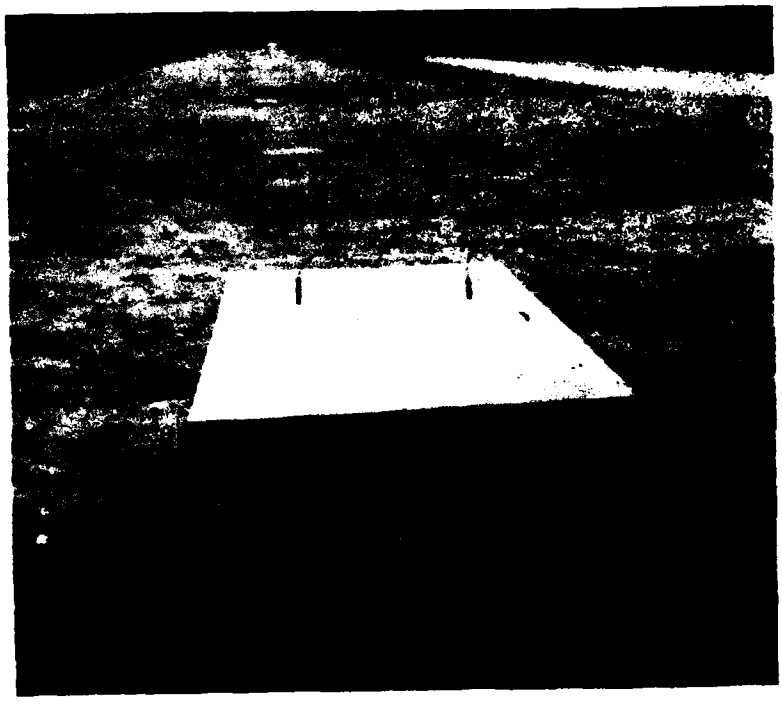
Test No. 10-85-01. Pretest Configuration for TNT Equivalency Testing of M31A1E1 Slotted Stick Propellant in a Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight

Appendix C

Test No. 10-85-01. Typical Posttest Results for TNT Equivalency Testing of M31A1E1 Slotted Stick Propellant in a Simulated Wooden Shipping/Storage Container with a 54.43-kg (120-lb) Charge Weight

Test No. 10-85-05. Pretest Configuration for Using Two 2.72-kg (6-lb) Boosters

Appendix C



Test No. 10-85-05. Pretest Configuration for TNT Equivalency Testing of M31A1E1 Slotted Stick Propellant in a Simulated Wooden Shipping/Storage Container Using Two Boosters

Test No. 10-85-05. Posttest Results Showing Witness Plate from Detonation of 54.43-kg (120-lb) M31A1E1 Slotted Stick Propellant Using Two Boosters

Test No. 10-85-07. Posttest Results Showing Witness Plate from Detonation of 54.43-kg (120-lb) M31A1E1 Slotted Stick Propellant Using Two Boosters

Test No. 10-85-05. Posttest Results Showing Witness Plate from Detonation of 54.43-kg (120-lb) M31A1E1 Slotted Stick Propellant Using Two Boosters

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